APPARATUS AND METHOD FOR MAKING
FOUNDRY SAND ARTICLES
12 Claims, 19 Drawing Figs.

ABSTRACT: Apparatus for making foundry sand articles such as sand cores includes a mold box having separable box sections defining a mold cavity therebetween, a sand magazine for filling the mold cavity to form a molded article therein, gas manifolds for supplying gas to the mold cavity and exhausting gas therefrom to harden the molded article, stripper pins associated with the gas manifolds and insertable through the manifolds and the mold box sections for stripping the molded article from the sections, and relative movement means for disposing the sand magazine and the gas manifolds alternately adjacent the mold box, for separating the mold box sections, and for inserting the stripper pins through the manifolds and the mold box sections.

A method of making foundry sand articles in a mold box having separable box sections defining a mold cavity therebetween includes the steps of positioning a sand magazine adjacent to the mold box in communication with the mold cavity, blowing sand containing a hardenable binder from the magazine into the mold cavity to form a molded article therein, separating the mold box and the magazine, positioning gas manifolds adjacent to the mold box sections in communication with the mold cavity, blowing a gaseous hardening agent from a gas manifold into the mold cavity preferably at progressively increasing pressure to thereby harden the molded article while exhausting gas to another manifold, separating the mold box sections, and removing the molded article from the mold box by inserting stripper pins through the gas manifolds and the mold box sections.
APPARATUS AND METHOD FOR MAKING FOUNDRY SAND ARTICLES

BACKGROUND OF THE INVENTION

This invention relates to apparatus and a method for making foundry sand articles, particularly sand cores. More particularly, the invention relates to apparatus and a method for making sand articles by a "cold box" process, wherein sand containing a hardenable binder is blown into a mold box to form a molded article therein, and a gaseous hardening agent for the binder is introduced into the mold box to thereby harden the molded article without necessity for the application of heat.

The manufacture of shell cores and molds from sand coated with a hardenable binder is a well-developed art. Thus, for example, an automatic core-making machine for making cores by a "hot box" process is disclosed in U.S. Pat. No. 3,096,547 granted to William A. Hunter and the present inventor. The hot box process employs sand coated with a thermosetting resinous binder, and molded articles are hardened in mold boxes by the application of heat.

While the hot box processes have achieved widespread success, certain disadvantages are inherent in the processes. Thus, production rates and variations in core thickness are limited by heat transfer rates. The molded articles are subject to thermal stresses. Mold boxes must be constructed of heavy cast iron, so as to retain heat and avoid warping. Operations are conducted with open gas flames at high temperatures.

Cold box processes also have been provided wherein molded sand articles containing a hardenable binder were hardened or cured by contact with a gaseous hardening agent. For example, one such process employed sodium silicate as the binder and carbon dioxide as the hardening agent. The characteristics of the early cold box sand articles were less desirable, and consequently, articles made by hot box processes have been preferred.

More recently, developments in resinous binders have resulted in the introduction commercially of binder materials which may be hardened by a gaseous hardening agent in a cold box process to produce very desirable foundry sand articles. The sand articles may be produced without the disadvantages of the hot box processes. Inasmuch as heat transfer is not a factor, the hardening or cure time is substantially less than in a hot box process, and the sand articles can have widely varying thicknesses. Thermal stress is not present in the sand articles. The mold boxes may be constructed of diverse materials.

SUMMARY OF THE INVENTION

The present invention provides a new and improved apparatus and method for making foundry sand articles by a cold box process. More particularly, the apparatus and method of the invention may be utilized for the manufacture of sand articles by a process wherein foundry sand containing a hardenable binder is contacted with a gaseous hardening agent for the binder either according to the early processes or utilizing the more recent developments in binder materials.

The apparatus of the invention includes a mold box having separable box sections defining a mold cavity therebetween, a gas manifold adapted to be disposed adjacent the mold box in sealed relationship thereto and communicating with the mold box cavity for conducting gas under pressure between the mold cavity, and means for metering the gas manifold and the mold box for relative movement between them. The gas manifold also encloses sand filling openings provided in the mold box, when the manifold is adjacent to the mold box. In a preferred embodiment for use with a noxious or hazardous gaseous hardening agent, two gas manifolds are provided, and they are adapted to be disposed adjacent respective mold box sections in communication with the mold cavity for conducting gas under pressure from either manifold to the mold cavity and from the mold cavity to the other manifold, with one of the manifolds enclosing the sand filling openings and being separable from its adjacent mold box section to permit access to the filling openings.

The apparatus more preferably includes a sand magazine for filling the mold cavity, and means for separating the gas manifold, the sand magazine and the mold box for relative movement whereby the manifold and the magazine may be disposed alternately adjacent the mold box sections.

The apparatus also preferably includes pilot-operated pressure regulating valve means in a gas supply line connected to one of the gas manifolds, for progressively increasing the gas pressure therein to harden a molded article in the mold cavity adjacent the points of introduction of the gaseous hardening agent sufficiently to prevent substantial erosion of the molded article thereat.

Another novel feature of the invention involves the provision of stripper pins associated with either of the gas manifolds and insertable through the manifolds and their adjacent mold box sections for stripping a molded article therefrom. Preferably, the separable gas manifold and its associated stripper pins, the sand magazine, and the mold box are mounted for relative movement whereby the manifold and stripper pins, and the magazine may be disposed alternately adjacent the mold box.

In the more specific embodiments of the invention, the apparatus is constructed to perform all operations pertaining to the formation of the sand articles at a single location or within a single mold box area or station, employing but one mold box which remains in the working area, with sand filling, binder hardening, separation of the mold box sections, and stripping taking place within the working area while the cooperating apparatus is disposed in superposed relationship and relative vertical movement is effected between the parts. Certain instrumentality is shifted laterally into and out of the working area during the cycle of operation. In this respect, the apparatus of the present invention is similar to the apparatus of the aforementioned U.S. Pat. No. 3,096,547, preserving the various advantages of such apparatus. The new apparatus is likewise adapted for fully automatic cyclic operation and continuous manufacture of sand articles.

Furthermore, the new apparatus embodies a novel combination of structure for making foundry sand articles most efficiently by a cold box process.

The invention provides a method of making a foundry sand article in a mold box having separable box sections defining a mold cavity therebetween which includes the steps of positioning a sand magazine adjacent to the mold box in communication with the mold cavity, blowing sand containing a hardenable binder from the magazine into the mold cavity to form a molded article therein, separating the mold box and the magazine, positioning a gas manifold adjacent to the mold box in communication with the mold cavity, blowing a gaseous hardening agent for the binder from the magazine into the mold cavity to harden the molded article, and separating the mold box sections for removal of the molded article from the mold box. It is further preferred when employing a noxious or hazardous gaseous hardening agent to interpose the mold box between two gas manifolds adjacent respective mold box sections in communication with the mold cavity, in which case the hardening agent may be blown into the mold box from either of the manifolds and exhausted to the remaining manifold.

The gaseous hardening agent preferably is blown into the mold cavity at progressively increasing pressure, whereby the molded article hardens adjacent the points of introduction of the hardening agent sufficiently to prevent substantial erosion of the molded article thereat.

The method preferably includes the additional step of removing the article from the mold box while separating the mold box sections by inserting stripper pins through at least one of the gas manifolds and through the adjacent mold box section.

Employing the apparatus and method of the invention, foundry sand articles are manufactured at a high rate of production, accurately, with minimum molding materials, and with few rejects. Equipment, space, and labor requirements also are minimized. If desired, the apparatus may be con-
structed by conversion or adaptation of existing hot box apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

The attached drawings illustrate a preferred embodiment of the apparatus and method of the invention, without limitation thereto. In the drawings, like elements are identified by like reference symbols in each of the views, and:

FIG. 1 is a front elevational view of apparatus for making foundry sand articles according to the invention, with parts broken away and in section, illustrating the apparatus as it appears at the start of a cycle of operation and, similarly, at the end of the cycle;

FIG. 2 is a vertical sectional and elevational view of the apparatus, taken substantially on line 2–2 of FIG. 1, illustrating a carriage in the apparatus shifted to a forward position as takes place during the start of operation;

FIG. 3 is an enlarged fragmentary front elevational view of the apparatus, with parts broken away and in section, illustrating the disposition of the parts during sand filling or blowing, taken substantially on line 3–3 of FIG. 12;

FIG. 4 is an enlarged fragmentary front elevational view of the apparatus, with parts broken away and in section, illustrating the disposition of the parts during sand hardening or curing, taken substantially on line 4–4 of FIG. 15;

FIG. 5 is a similar view illustrating the disposition of the parts during cope stripping, taken substantially on the line 5–5 of FIG. 16 with the parts in the positions assumed by them just subsequent to the positions shown in the latter view;

FIG. 6 is a similar view illustrating the disposition of the parts at the completion of drag stripping and at the end of a cycle of operation, taken substantially on line 6–6 of FIG. 18;

FIG. 7 is an enlarged fragmentary side elevational and partly sectional view of the apparatus, with parts broken away, illustrating the parts disposed as shown in FIG. 4;

FIG. 8 is a further enlarged fragmentary vertical sectional view of a portion of the apparatus illustrated in FIG. 4;

FIGS. 9 and 10 are similar views of other portions of such apparatus, taken at right angles to the view of FIG. 8;

FIG. 11 is a fragmentary perspective view of separated mold box sections, particularly illustrating the top of a drag section with stripper pins extending therethrough;

FIGS. 12–18 are schematic fragmentary side elevational views of the apparatus, illustrating successive positions of the parts from the sand filling operation to completion of drag stripping at the end of a cycle; and

FIG. 19 is a diagrammatic representation of equipment for supplying air and gaseous hardening agent to machine instrumentalities and exhausting the same therefrom.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, particularly FIGS. 1 and 2, a preferred embodiment of apparatus for making foundry sand articles according to the invention includes a core-making machine 20 and air and gas supply equipment generally designated by the number 22, the latter also being illustrated diagrammatically in FIG. 19. The apparatus is mounted on a foundry floor 24 or other suitable supporting surface, which preferably is provided with a clearance well 26 beneath the machine.

GENERAL ORGANIZATION OF THE MACHINE

The core-making machine 20 includes in its general organization a housing 28 of generally C-shaped profile, mounted on the floor. An area W at the front of the machine and intermediate the top and bottom of the housing is referred to as the working area or station. A ram assembly 30 is mounted at the bottom of the housing and extends upwardly into the working area. A sectional mold box or core box 32 is disposed in the working area and vertically movable therein, in superposed relation to the ram assembly.

The mold box includes an upper rectangular cope section or cope 34 and a lower rectangular drag section or drag 36. The drag section is a component of a combined drag unit 37 that also includes a gas manifold 39 for the drag section. The drag unit 37 is moved vertically in the working area by the action of the ram assembly 30. The drag unit engages the cope section when raised, to close the mold box, and the complete mold box then is moved by the ram assembly.

A carriage 38 is mounted for horizontal reciprocal movement above the mold box adjacent the top of the housing 28. A rearwardly disposed sand magazine 40 and a spaced, forwardly disposed, cope gas manifold and stripper assembly 42 are mounted on the carriage for movement therewith. The stripper part of the assembly 42 is mounted to move downwards and upwards with respect to the manifold part of said assembly. The carriage is movable between a forward position wherein the sand magazine is in superposed relationship to the mold box 32, as illustrated in FIGS. 2 and 12, and a rearward position wherein the cope gas manifold and stripper assembly is disposed in superposed relationship to the mold box, as illustrated in FIG. 13.

A blow valve 44 is mounted at the top of the housing 28 over the working area W, and a sand hopper 46 is mounted at the top of the housing to the rear of the machine and spaced from the blow valve. When the carriage 38 is in its forward position, the sand magazine 40 is in vertical registry or alignment with the blow valve therebelow. When the carriage is in its rearward position, the sand magazine is in vertical registry with the sand hopper therebelow.

It is a feature of the present invention that the new apparatus may be provided and the new method conducted by conversion of existing hot box apparatus. Thus, the illustrative embodiment includes various structural components which are the same or essentially the same as corresponding components of the machine described in the aforementioned U.S. Pat. No. 3,096,547. Except for structural variations and design changes, the housing 28, the ram assembly 30, the carriage 38, the sand magazine 40, the blow valve 44, and the sand hopper 46 and associated structure are basically the same as in the patent. Accordingly, such structure will not be described in detail except with reference to certain variations, but the description will relate more particularly to the novel structure of the present invention and its cooperation with the prior structure.

DESCRIPTION OF THE MACHINE STRUCTURE

The housing 28 more specifically includes two spaced parallel sectional sidewalls 50 and 52 mounted on the floor 24. The walls are connected at the top of the housing by transversely extending beams 53 and at the bottom of the housing by transversely extending supporting structure 54. The beams 53 support the blow valve 44 and two longitudinal reaction bars 51 mounted on the bottoms of the beams and spaced from opposite sides of the blow valve. The supporting structure 54 supports the ram assembly 30. Additional members connecting the walls include crossbars 55–58. A cover panel 54 extends between the sidewalls at the upper front of the housing.

The ram assembly 30 includes a cylinder holder 60 secured on the upper surface of the supporting structure 54. A single acting hydraulic clamp cylinder 62 is fixedly mounted on the holder, and the cylinder extends through the holder and the supporting structure 54 into the well 26. A cylindrical plunger 64 extends upwardly from the clamp cylinder and is vertically reciprocally movable therein. A circular ram head 66 is fixedly mounted on the upper end of the plunger and extends laterally therefrom. Guide rods 67 extend downwardly from the head into the holder 60. A mold box supporting table or platform 68 is mounted on the ram head and secured thereto by studs 70 extending through the head into the table. The drag unit 37 is secured on the table 68 for vertical reciprocal movement by the plunger 64. Referring also to FIG. 10, the drag unit includes the drag section 36 forming the top.
of the unit, a hollow body 72 integral with the drag section and having a manifold cavity 74 therein adjacent to the drag section, a bottom closure plate 76 secured to the body as by screws 78. The body 72 and the closure plate 76 form the drag gas manifold 39. A drag mold cavity 80 is formed in the upper surface 81 of the drag section 36, corresponding to the contours on one side of the sand article or articles to be molded. FIG. 11 shows a representative mold cavity 80.

The drag unit 37 is supported by a pair of spacer blocks 82 and 84 mounted on the blocks and extending laterally therefrom. The spacer blocks and the foot plate are secured to the drag unit in a unitary assembly by screws or other fastening means, not shown. The assembly is secured on top of the table 68 by screw-fastened clamps 86 fastened to the table and extending over the edges of the foot plate to clamp the unit in place.

As seen most clearly in FIGS. 10 and 11, the drag unit 37 is provided with a series of vertically extending cylindrical stripper pin openings 88 in the drag section 36, and a series of stripper pin openings 90 in alignment therewith in the closure plate 76. Drag stripper pins 92 are fixedly mounted on a stripper plate 94 (FIGS. 1—7) beneath the drag section 37, and the pins extend upwardly through the aligned openings 88 and 90. The stripper pins substantially block the openings beneath the drag mold cavity 80 during molding, and serve to strip a molded article from the cavity thereafter. The openings and the pins are arranged at selected locations for cleanly stripping a molded article and thereafter supporting the article above the drag unit.

The drag stripper plate 94 is vertically reciprocably movable in the space between the drag unit 37 and the foot plate 84. In its lowermost position, the stripper plate is seated on spacer blocks 95 secured on top of the foot plate. The spacer blocks serve to gauge the positions of the stripper pins 92, so that their upper ends are flush with the wall of the mold cavity 80.

Two arresting posts 96 are adjustable mounted on the cylinder supporting structure 54 and extend upwardly therefrom on opposite sides of the drag unit 37 and its supporting members. The drag stripper plate 94 extends laterally beyond the spacer blocks 92 for abutting engagement with the upper ends of the posts as the stripper plate is lowered with the remainder of the assembly by the plunger 64. The drag unit 37 and the drag stripper plate 94 are lowered together by the plunger until the stripper plate abuts on the posts, at which time movement of the stripper plate is arrested while the drag unit continues to descend as the plunger is lowered. In this manner, the drag stripper pins 92 are held stationary while the drag section 36 is lowered, to strip a molded article from the drag section and suspend the article on the stripper pins.

The drag unit 37 includes provision for venting gas from the mold cavity 80 and exhausting the gas from the unit. Referring to FIG. 10, the stripper pin openings 88 in the drag section 36 are dimensioned to provide clearance from the stripper pins 92, thereby serving also as passageways to permit gas to pass from the mold cavity 80 into the manifold cavity 74. In addition, relatively small vent orifices or openings 100 extend between the mold cavity 80 and the manifold cavity 74 and provide gas passageways therebetwen. The orifices are covered by sand blocking screens 102. As seen in FIG. 11, the orifices covered by the screens are distributed throughout the area of the mold cavity 80 in selected locations, so that the orifices together with the stripper pin openings 88 distribute the gas flow throughout the cavity.

A gland seal 104 is mounted on the closure plate 76 adjacent each of its stripper pin openings 90 for sealing engagement with the stripper pin 92 therein, to retain the gas in the manifold cavity 74. The seal is a resilient O-ring member of channel cross section, and it is held in place by a screw-fastened annular retaining disc 105. A pair of threaded exhaust openings 106 are formed in the back wall of the drag manifold body 72 in communication with the manifold cavity 74. Exhaust hoses 110 are secured to the pipes for conveying the exhaust gas from the manifold cavity.

Referring particularly to FIGS. 7, 10 and 11, guide rods 112 are mounted adjacent the four corners of the drag stripper plate 94 and extend upwardly through corresponding openings in the closure plate 76 and the body 72, for vertical movement in the openings. Tubular locators 114 are mounted in the drag section 36 and extend upwardly from its upper surface 81 on opposite sides thereof. Four rectangular stripper plates 116 are set into the upper surface 81 adjacent the four corners thereof.

Referring to FIGS. 3, 4, 9 and 10, the bottom surface 120 of the cope section 34 is seated on the upper surface 81 of the drag section 36 around the periphery of the mold box 32 when the box is closed. The cope section extends laterally beyond the drag section on opposite sides thereof. The parting line or plane 122 of the mold box is horizontal. At other times, as illustrated in FIGS. 1, 2, 5 and 6, the cope section is seated on arresting pins 124 and 126 at the four corners thereof. The arresting pins are adjustably mounted on arresting bracket assemblies 128 secured to the housing sidewalks 50 and 52. The arresting pins 124 at diagonal corners of the cope are provided with frustoconical centering heads 130 which are received in corresponding recesses 132 in the bottom surface 120 of the cope section.

Referring to FIGS. 4—6 and 9, a mold cavity 134 is formed in the bottom surface 120 of the cope section 34 and, in the illustrative embodiment, integral draw members 136 project downwardly below the bottom surface for entry into the drag mold cavity 80 to form hollow or recessed molded articles. The cope section, similarly to the drag section 36, is provided with vertically extending sand filling and stripper pin openings 138, and gas inlet and vent orifices 140 which extend through the cope from its upper surface 141 to the mold cavity. The orifices are covered by sand blocking screens 142. The filling and stripper pin openings, and the orifices are arranged about the mold cavity suitably for sand filling, stripping and gasging purposes. The filling and stripper pin openings 138 are provided with enlarged outer openings 144 terminating in frustoconical portions, for insertion of sand blow tubes, as subsequently described.

An inflatable resilient annular gasket 150 of suitable material, such as pouried foam rubber, is secured along its sides in an annular groove 152 in the cope bottom surface 120. An annular duct 154 is formed in the cope section, and it communicates with the bottom of the gasket and with a pressurizing pipe 156 mounted in a corresponding threaded opening 158 in the cope section. An air hose 160 is connected to the pipe. When air pressure is applied to the inner surface of the gasket, it is inflated, thereby forming a seal between the cope section 34 and the drag section 36 of the mold box when the former is seated on the latter.

Referring also to FIG. 7, cylindrical openings 162 are provided in the cope section 34, for receiving the drag stripper guide rods 112. Cylindrical openings 164 also are provided in the cope section for receiving the locators 114 on the drag section.

Referring to FIGS. 1 and 2, the sand magazine 40 includes hollow upper and lower sections 174 and 176. The carriage 38 includes a pair of longitudinally extending plates 170 which form opposite sides of the upper magazine section 174 and are secured together forwardly of the magazine by cross赁 172. Wheel mounting brackets 182 are mounted on the carriage plates 170 on opposite sides of the carriage, and front wheels 184 are rotatably mounted thereon. Rear wheels 186 are similarly mounted on the rear of the sand magazine 40.

Two horizontal rails 178 are mounted on support brackets 180, in turn mounted on the inner surface of the housing sidewalks 50 and 52. The rails extend from the back of the machine 20 to points spaced forwardly of the housing sidewalks 50 and 52. The carriage wheels 184 and 186 travel on the rails 178. The carriage 38 is thus horizontally reciprocably movable between front and rear positions, illustrated respectively in FIGS. 12 and 13.

A double acting air cylinder 200 is provided for reciprocating the carriage 38. The cylinder is secured on rearwardly pro-
jecting mounting brackets 202, in turn secured to the back crossbar 55. A piston rod 206 extending from the cylinder is connected to a boss 208 on the upper section 174 of the sand magazine. As the cylinder is operated to extend or withdraw the piston rod, the carriage is moved forwardly or rearwardly. The portions of the carriage are regulated by the piston stroke, and front and rear shock absorbers 203 and 204 arrest movement of the carriage. The front shock absorber 203 is mounted on a bracket 205 secured to and depending from the front beam 53, so that the shock absorber engages the front of the upper section 174 of the sand magazine. The rear shock absorber 204 is mounted on a bar 207 secured to and depending from the back crossbar 55, so that the shock absorber engages the rear of the lower section 176 of the sand magazine.

The first sand article-forming operation in the operating cycle is sand filling or blowing, and for this operation, the carriage 38 is in its forward position illustrated in FIGS. 2, 3 and 12. The sand magazine 40 is in superposed relationship to the mold box 32 and disposed beneath the blow valve 44 in the working area \( W_a \) in vertical alignment with both structures. The copé gas manifold and stripper assembly 42 is disposed in an out of the way position forwardly of the working area.

The upper section 174 of the sand magazine is constructed for making sealing engagement with the blow valve 44, as described in U.S. Pat. No. 3,096,547. A blow plate 210 is secured to the bottom of the lower section 176, and blow holes 212 are provided therein for discharging sand from the magazine. Sand blow tubes 214 having peripheral mounting flanges 216 are secured to the bottom of the blow plate in register with the blow holes. The blow tubes are of various lengths, according to the contour of the cope mold cavity 134. The blow tubes have frustoconical portions which seat in the enlarged openings 144 in the cope section and terminal short cylindrical portions which extend in the filling and pin openings 138 to substantially flush with the cope mold cavity 134, when the magazine and the mold box 32 are brought together for sand filling. The blow tubes are employed to eliminate protruberances on the molded articles which otherwise are formed in the filling openings and must be removed from the finished articles.

As seen in FIGS. 2 and 3 flat spacer blocks 220 and spacer block and locator members 222 are mounted on the bottom of the blow plate 210, for providing clearance between the blow plate and the cope section 34 when brought together. Projecting portions of the locator members are received in corresponding holes in the cope, which are not shown. Subsequent operations are conducted with the carriage 38 in its rear position illustrated in FIGS. 1, 4—7, and 13—18. The sand magazine 40 then is in vertical alignment with the sand hopper 46 for receiving a charge of sand therefrom. The cope gas manifold and stripper assembly 42 is disposed in the working area \( W_a \) in vertical register or alignment with the mold box 32.

The sand hopper is mounted on the housing sidewalls 50 and 52 by brackets 224, and is further supported by a bracket 226 secured to a beam 53. Cylinder mounting bars 230 are mounted on the bottom of the hopper and project rearwardly therefrom. Air cylinders 232 are mounted on the bars, and piston rods 234 extend therefrom. The piston rods are pivotally connected to cranks 246, and the cranks are fixed to the outer ends of crank shafts 248 mounted on the hopper. A gate 250 is mounted on the crank shafts within the hopper, by means of arms 252 fixed to the shafts. The gate is moved from a position closing a discharge opening 251 in the hopper, as shown in full lines, to a discharge position, shown in broken lines, by operation of the cylinders. In this manner, the sand magazine 40 is refilled each time it is moved from the working area \( W_a \) to the rear position beneath the sand hopper.

The cope gas manifold and stripper assembly 42 includes a mounting frame 254 consisting of four uprights 255 having laterally extending feet 256, side crosspieces 257, and front and rear crosspieces 258, all secured together by welding or other suitable means. Upwardly extending thrust screws 253 are adjustably mounted on top of the uprights 255 for engagement with the reaction bars 51, as subsequently described.

The mounting frame is suspended from the crossbars 172 on the carriage 38 and the frame is extending through spacer blocks 261 secured to the crosspieces 258. A rectangular cope gas manifold 260 is suspended from the mounting frame 254, being secured to the feet 256 at the four corners of the manifold by screws 263. Referring to FIGS. 8 and 9, the cope gas manifold is a plate like body provided with a manifold cavity 262 on its bottom surface 265. The cavity faces the upper surface 141 of the cope section 34 and covers an area substantially the same as that of the cope-mold cavity 134 with similar dimension. When the gas manifold and the cope section are brought together, the manifold cavity encloses the sand filling openings 138 and the orifices 140.

A threaded bore 264 is provided in the cope gas manifold, leading from one side thereof to the manifold cavity. A flexible supply line 266 is threadedly secured in the bore. An annular groove 268 is formed in the bottom surface 265 of the manifold, and it surrounds the manifold cavity. A compression gasket 270 is mounted in the groove and forms a seal between the bottom surface of the manifold and the upper surface 141 of the cope section.

Cylindrical stripper pin openings 272 are provided in the gas manifold 260, in vertical alignment with the sand filling openings 138 in the cope section 34 when the members are in register. Cope stripper pins 274 are inserted in the openings and are vertically reciprocally movable therein. Gland seals 276 and retaining discs 277 are mounted on the gas manifold and form a seal between the manifold and the pins. The cope stripper pins 274 are rigidly mounted and depend on a rectangular cope stripper plate 278.

Referring particularly to FIGS. 1 and 2, the cope stripper plate 278 is vertically reciprocally moved by a double-acting cope stripping air cylinder 280 having a piston rod 281 connected to the stripper plate. The cylinder is mounted on a mounting plate 282 secured centrally on the mounting frame 254 to bars or pads 283 fixed to the front and rear crosspieces 258. The piston rod extends downwardly through the mounting plate to the stripper plate.

Referring also to FIG. 7, stop rods 284 are secured to the cope stripper plate adjacent the corners thereof, and the rods extend downwardly therefrom through openings 280 in the gas manifold 260. The gas manifold openings register with openings 288 through the cope 34. The rods are arranged to abut on the striker plates 116 on the drag section 36. Spacer blocks 290 are secured to the underside of the cope stripper plate 278, for limiting its downward movement by engagement with the gas manifold.

Guide rods 292 are secured to the gas manifold 260 adjacent opposite side edges thereof, and the rods extend upwardly therefrom through the cope stripper plate 278. The rods are surmounted by enlarged heads 294. The rods serve to guide the stripper plate in vertical movement, and the heads limit upward travel of the plate.

**DESCRIPTION OF THE AIR AND GAS SUPPLY EQUIPMENT**

Referring to FIGS. 1 and 19, the air and gas supply equipment 22 includes a gas generator 300, a scrubber 302, and a pipe or conduit 304 leading from an air pressure source, not shown. The generator and the scrubber are mounted on a stand 305. The gas generator includes a tank 306 having a foraminous distributor 307 mounted in the lower end thereof, an air supply pipe 308 inserted into the bottom of the tank below the distributor, and a discharge pipe 310 inserted into the top of the tank. A vaporizable liquid hardening agent 312 for the sand binder is contained in the tank under pressure. In the illustrative embodiment, the hardening agent is a catalytic or reactive agent, which causes the synthetic resinous binder to harden or cure rapidly.
The air pipe 304 is connected to a manifold conduit 314, and the generator supply pipe 308 is connected to the conduit. A manual pressure regulating valve or regulator 316 having a pressure gauge 317, and a check valve 318 are incorporated in the conduit 314, between the air pipe 304 and the generator supply pipe 308. Air under pressure is supplied to the gas generator 300, and bubbled through the liquid 312 to vaporize the liquid in the air stream. The air laden with gaseous hardening agent exits through the discharge pipe 310, through a check valve 319 and a pilot-operated manifold pressure regulating valve 320 to the gas supply line 266 leading to the gas manifold 260. A pressure gauge 322 is mounted in the gas supply line.

A generator bypass conduit 324 is connected to the manifold conduit 314 and to the gas supply line 266. A solenoid valve 326 and a check valve 328 are mounted in the bypass conduit. The bypass conduit serves to supply air directly to the gas manifold 260, bypassing the gas generator 300.

A pilot air line 330 is connected to the air pipe 304 and to the manifold pressure regulator 320. A pilot solenoid valve 332 and a flow control valve 334 are mounted in the pilot air line. As illustrated schematically in FIG. 19, the flow control valve 334 includes a flow regulating orifice 336 which restricts air flow in the line and causes pressure to increase progressively on the downstream side of the line. The flow control also includes a check valve 338 for venting the line in the opposite direction of flow.

The pilot air line 330 is connected to the manifold pressure regulator 320 in a conventional manner for regulating the operation of the pressure regulator. As the pressure builds up in the pilot air line 330, the pressure regulator controls the gas flow therethrough to provide progressively increasing pressure on the downstream side thereof, i.e., in the gas supply line 266 leading to the gas manifold 260.

A core seal air line 340 is connected to the manifold conduit 314 and to the cope airstream 160, and a solenoid valve 342 is mounted in the air line. A blow valve air line 344 (FIG. 1) is connected to the air pipe 304 and to the blow valve 44. A pilot air line 346 also is connected to the blow valve. The blow valve is constructed and operated as described in the above-identified patent.

The scrubber 302 includes a closed tank 348 containing a liquid 350 for removing noxious or hazardous hardening agent from the exhaust gases removed from the mold box 32. The exhaust hoses 110 from the drag unit 37 are connected to an inlet pipe 352 to the scrubber. The inlet pipe extends to the bottom of a foraminous header 353 in the lower end of the tank. A bypass solenoid valve 354 is connected to the inlet pipe by a branch line 355, and an exhaust fitting 356 is connected to the solenoid valve. Gases from the mold box are either bubbled through the liquid 350 in the tank or vented directly to the atmosphere through the bypass solenoid valve and the exhaust fitting 356. The gases freed of hardening agent in the scrubber are vented to the atmosphere through a vent pipe 358 at the top of a scrubber. As illustrated schematically in FIG. 19, the scrubber is bypassed through operation of the solenoid valve 354 by air conducted from the blow valve 44.

In addition to the foregoing apparatus, the air and gas supply equipment 22 is provided with manually operated valves 360 at desirable locations in the flow conduits.

OPERATION

The components of the machine 20 are in the positions illustrated in FIGS. 1, 6 and 18 at the beginning and at the end of each cycle of operation. In the first operating step, the mold box 32 is positioned adjacent to the sand magazine 40 with the magazine in register with the cope section 34 of the mold box, preparatory to filling the mold box with resin-coated sand. This position is illustrated in FIGS. 3 and 12.

In this step, the carriage cylinder 200 is operated to extend its piston rod 206 and move the carriage 38 forwardly, as illustrated in FIG. 2. The sand magazine 40 is disposed in the working area W, between the upper blow valve 44 and the lower mold box 32. At the time the carriage cylinder is operated, the clamp cylinder 62 also is operated, extending the plunger 64 and elevating the drag unit 37 thereon.

The drag unit engages the cope section 34 and carries it upwardly off of the cope arresting pins 124 and 126. As the clamp cylinder 62 continues to extend the plunger 64, the assembled mold box is moved upwardly against the sand magazine 40, and the same combined filling openings 138 in the cope 34. The mold box lifts the magazine into sealing engagement with the blow valve 44, lifting the carriage 38 off of the rails 178. The apparatus then is in the condition illustrated in FIG. 3, ready for sand filling.

The blow valve 44 is operated to blow resin-coated sand from the sand magazine 40, through the blow holes 212 and the blow tubes 214, into the mold cavity defined by the cope and drag sections 34 and 36 therebetween, and constituting the adjoining cope and drag cavities 134 and 80 (see FIGS. 9 and 10). At this time, the drag stripper plate 94 is in its lowermost position relative to the drag unit 37, being seated on the spacer blocks 95. The upper ends of the drag stripper pins 92 are flush with the wall of the drag mold cavity 80, as illustrated in FIGS. 3 and 10.

The sand magazine 40 is separated from the cope section 34 by the spacer blocks 220 and 222, so that a space remains between the blow plate 210 and the upper surface 191 of the cope section. During blowing, air escapes through the gas inlet and vent orifices 140 in the cope section and is exhausted to the atmosphere between the sand magazine and the cope section. Air also escapes through the vent orifices 100 in the drag section 36, is collected in the drag manifold cavity 74, and is exhausted through the drag exhaust hoses 130. The drag exhaust air is permitted to escape through the exhaust fitting 356, by operation of the bypass solenoid 354 above the scrubber 302 (FIG. 1). Referring to FIG. 19, the bypass solenoid 354 is operated to move it out of its illustrative position into its alternate position, under the control of air from the blow valve 44.

A porous molded article or core 370 is formed in the mold box cavity. The article is, however, not hard or cured. The manner in which the molded article is formed, according to the foregoing description, is essentially the same as the manner of forming a molded article described in the above-identified U.S. Pat. No. 3,096,547, except for the presence of instrumentality peculiar to the present invention.

Continuing in the cycle of operation, and referring particularly to FIG. 13, the plunger 64 is lowered to lower the mold box 32 and the sand magazine 40 together, until the carriage 38 is seated on the rails 178. The mold box then is lowered away from the sand magazine 40. The carriage 38 is moved rearwardly by operation of its cylinder 200, bringing the cope gas manifold and stripper assembly 42 into the working area W in vertical alignment with the mold box. At the same time, the sand magazine is moved to a receiving position beneath the sand hopper 46, and the gate cylinders 232 are operated to open the gates 250 and refill the magazine. In this connection, the consistency of the resin-coated sand is such that it will not escape from the blow tubes 214 unless the sand magazine is under air pressure.

Referring particularly to FIG. 14, the plunger 64 next is extended to raise the mold box 32 into contact of the upper surface 141 of the cope section 34 therewith at the lower surface of the gas manifold 260. The plunger force raises the carriage 37 off of the rails 178, until the thrust screws 253 engage the reaction bars 51 (see FIG. 1).

Referring to FIG. 15, the cope stripping air cylinder 260 next is operated to extend its piston rod 281 and thereby lower the cope stripper plate 278 and insert the cope stripper pins 274 into the sand filling openings 138, so that the lower ends of the stripper pins are flush with the wall of the cope mold cavity 134. This condition is illustrated in FIGS. 4 and 9.
Referring to FIG. 7, the positions of the cope stripper pins 274 are gauged by the stop rods 284, abutting on the striker plates 116 in the upper surface 81 of the drag section 36. The stripper plate 278 is spaced below the heads 294 of the guide rods 292. The cope cylinder 260 and 300 continues to maintain pressure on the cope stripper plate 278, with the cylinder reaction force also transmitted to the reaction bars 51 by the thrust screws 253.

Referring to FIGS. 1, 9 and 10, the solenoid valve 342 in the cope seal air line 340 is opened to admit air to the hole 160 and the cope duct 154, and inflates the gasket 150 to provide a gas tight seal between the cope section 34 and the drag section 36. The mold box 32 then is in condition for hardening or curing the molded article 370 therein.

The pilot solenoid valve 332 is open to admit air to the flow control 334 and operate the manifold pressure regulator 320. Air is bubbled through the liquid hardening agent 312 in the gas generator tank 306, forming a gaseous mixture of air and hardening agent. The manifold pressure regulator 320 opens progressively for progressively increasing the gas pressure in the gas supply line 266 and in the gas manifold cavity 262. There is a corresponding progressive increase in the pressure of the gas supplied to the mold box cavity through the gas inlet orifices 140 and the sand filling openings 138 around the cope stripper pins 274.

The orifices 140 and the filling openings 138 are distributed throughout the cope and drag sections, as illustrated for the drag section 36 in FIG. 11, to distribute the gas containing hardening agent throughout the porous molded article 370 in the cavity. In order to provide rapid hardening, the gas is supplied at substantial pressure, e.g., about 40 p.s.i. gauge. It has been found that when the gas is admitted at relatively high pressure initially, the velocities through the orifices and filling openings are such as to erode the unhardened article 370 at the points of introduction of the gas. It has been found further that when the gas is blown into the mold box at progressively increasing pressure, the molded article hardens adjacent the points of introduction of gas sufficiently to prevent substantial erosion of the molded article at such points. Thus, the article hardens rapidly and sufficiently to withstand the relatively low initial gas pressures, and hardening increases progressively with the progressive increase in gas pressure to withstand the increasing gas velocities and produce accurately molded articles at a high hardening rate.

Referring also to FIG. 10, the gas containing hardening agent penetrates the molded article 370, and the mold cavity through the vent orifices 100 in the drag section 36 and through the drag stripper pin openings 88 around the drag stripper pins 92, and is collected in the drag manifold cavity 74. The exhaust gas flows from the manifold cavity to the exhaust hoses 110 and to the scrubber inlet pipe 352. The exhaust gases are bubbled through the liquid 350 in the mother tank 348, removing residual hardening agent, and the resulting air freed of hardening agent is vented to the atmosphere through the vent pipe 358. At this time, the air and gas supply equipment 22 is in the condition illustrated in FIG. 19.

The cope gas manifold 260, the cope section 34, the cope stripper pins 274, the drag section 36, the drag gas manifold 300, and the drag stripper pins 92 are engaged in tightly sealed relationship while the gaseous hardening agent is blown into and exhausted from the mold box 32. Thus, the compression gasket 270 provides a tight seal between the cope gas manifold 260 and the upper surface 141 of the cope section while the mold box is urged against the gas manifold under the pressure of the plunger 64. The inflatable gasket 150 is maintained under pressure to provide a tight seal between the cope and drag sections around the mold cavity as the sections are clamped together by the plunger. The gland seals 276 on the cope gas manifold prevent escape of gas around the cope stripper pins 274, and the gland seals 194 on the drag manifold closure plate 76 prevent escape of gas around the drag stripper pins 92.

While the gaseous hardening agent is introduced from the cope gas manifold 260 and exhausted from the drag gas manifold 39, it will be apparent that the hardening agent could as well be introduced from the latter manifold and exhausted from the former manifold if desired, with appropriate changes in the connections to the air and gas supply equipment 22 and other minor structural variations.

In the illustrative embodiment of the method and apparatus, about one-half to 1 second elapses between the time that gaseous hardening agent is admitted to the gas supply line 266 from the manifold pressure regulator 320 to attainment of full pressure, about 40 p.s.i.g. Thereafter, a period of about five seconds is required for hardening the average core. It will be seen, therefore, that production is greatly accelerated employing the new method and apparatus.

Following the hardening operation, and referring to FIGS. 1 and 19, the pilot solenoid valve 332 is operated to exhaust air from the control 334 for the manifold pressure regulator 320, thus terminating the flow of hardening agent to the gas manifold 260. The generator bypass solenoid valve 326 is operated to supply air through the bypass conduit 324 and the gas supply line 266 to the gas manifold 260, for purging the system. The air is conducted from the drag unit 37 through the exhaust hoses 110 to the scrubber 302, from where it is directed to the atmosphere through the vent pipe 358. The purging operation takes about 5 seconds at about 40 p.s.i.g. air pressure, for average cores.

At the completion of purging, the generator bypass solenoid valve 326 is closed, cutting off the supply of air to the gas manifold 260. The solenoid valve 342 in the cope seal air line 340 is operated to close the line to the manifold conduit 314 and vent the cope air hose 160, releasing pressure on the inflatable gasket 150 in the cope section and breaking the seal between the mold box sections.

Referring to FIGS. 5 and 16, the plunger 64 next is lowered to lower the mold box 32 preparatory to stripping the hardened molded article 370 from the mold box. Initially, the mold box is lowered until the cope 34 is seated on the cope arresting pins 124 and 126, as shown in FIG. 16. The cope stripper plate 278 and the cope stripper pins 274 are moved downwardly under the continuing pressure of the cylinder 280, with the stop rods 284 continuing to bear on the slider plates 116, as shown in FIG. 7. With continued downward movement of the plunger 64, the drag unit 37 is lowered and vents the cope stripper pins 274 to the atmosphere through the vent pipe 358, thus stripping the molded article 370 from the cope 34 while the article remains on the drag 36, as illustrated in FIG. 5.

Referring to FIG. 17, as the plunger 64 continues to be lowered, the vertical separation of the drag unit 37 bearing the molded article 370 from the cope section 34 is increased. The cope stripper plate 278 is lowered by the cylinder 280 to its fullest extent, with the spacer blocks 290 (FIG. 5) engaging the upper surface of the gas manifold 260. The carriage 38 returns to the rails 178 as the plunger descends. The drag unit is lowered to the point where the drag stripper plate 94 engages the upper ends of the arresting posts 96.

Referring to FIGS. 6 and 18, the drag stripper plate 94 and the stripper pins 92 thereon remain stationary on the arresting posts 96 as the plunger 64 continues to be lowered and the drag unit 37 is lowered therewith. The molded article 370 remains stationary on the drag, while the drag stripper pins 274 strip the article from the drag section 36 and suspend the article on the stripper pins above the drag section. The cope stripping cylinder 280 then is operated to raise its piston rod 281 and the cope stripper plate 278 and stripper pins 274 therewith, out of the cope section 34. The cope stripper plate is elevated until its upper surface engages the heads 294 on the cope grips 292. The molded article 370 is ready for manual or mechanical removal, according to conventional procedures. Following application of a mold release or parting agent where necessary
The machine is ready for a new cycle of operation when the cycle commences by placing the machine in the condition illustrated in FIG. 12, and the new cycle and successive cycles are completed in the manner described above. The machine may be operated continuously and automatically in this manner, employing conventional timing and control instruments.

The apparatus and method of the invention may be employed for manufacturing foundry sand articles by various cold box processes. The illustrative embodiment is well adapted for the use of sand containing a hardenable resin binder, and a gaseous hardening agent of a noxious or hazardous nature requiring confinement of the gas. Exemplary commercially available resinous binders include a mixture of equal weight proportions of Isocure I and Isocure II (Archer Daniels Midland Company), employed in a binder proportion up to about 2 percent by weight of the sand. An amine hardening or curing agent, in particular, triethylenepropane is employed with such binder. In this case, the liquid 312 in the gas generator tank 306 is triethylenepropane, and the liquid 350 in the scrubber tank 348 is an aqueous acid such as phosphoric acid.

In foundry practice, various mold box designs are employed together with suitable sand blow plate and blow tube, and stripping pin arrangements. The invention is adaptable to a variety of mold box requirements, and the structure shown and described is merely illustrative.

Employing the invention, the various advantages of the cold box process are achieved and additional advantages are obtained, as described above. Production rates are high, typically 3 complete cycles a minute. In comparison, operation according to the above-identified patent employing the hot box process requires about three-fourths of a minute to 1 minute for each cycle.

While a preferred embodiment of the invention has been described and illustrated, it will be apparent to those skilled in the art that various changes and modifications in the apparatus and method may be made within the spirit and scope of the invention. It is intended that all such changes and modifications be included within the scope of the appended claims.

1. Apparatus for making foundry sand articles which comprises:
   a mold box having separable box sections defining a mold cavity therebetween and having a sand filling opening and gas passageways to said cavity;
   means mounting said mold box sections for relative movement between them;
   carriage means mounted for reciprocal movement relative to said mold box;
   means for effecting said reciprocal movement;
   a sand magazine for filling said mold box through said filling opening mounted on said carriage means for movement therewith;
   a first gas manifold mounted on said carriage means for movement therewith and adapted to be disposed adjacent one of said mold box sections in sealed relationship thereto and in communication with said passageways for conducting gas under pressure between the manifold and said mold cavity;
   a second gas manifold adapted to be disposed adjacent the remaining mold box section in sealed relationship thereto and in communication with said passageways for conducting gas under pressure between the manifold and said mold cavity;
   means for disposing said mold box alternately adjacent said magazine and said first manifold in respective alternate relative positions of said carriage means for alternately blowing sand containing a hardenable binder from said magazine into said mold cavity to thereby form a molded article therein, and blowing a gaseous hardening agent for said binder from one of said molded into said mold cavity and exhausting the hardening agent to the remaining manifold to thereby harden the molded article; and
   means for separating said mold box sections for removal of said molded article from said mold box.

2. Apparatus as defined in claim 1 including:
   stripper pins associated with said first manifold for relative movement with said carriage means and reciprocally moveable through the first manifold and said one box section for stripping a molded article from the one box section in one direction from said stripper pin movement; and
   means on said carriage means for reciprocating said stripper pins through said first manifold and said one box section.

3. Apparatus as defined in claim 1 including:
   a gas supply line connected to said one gas manifold; and
   pilot-operated pressure regulating valve means in said line for progressively increasing the gas pressure therein.

4. Apparatus for making foundry sand articles which comprises:
   a mold box having separable upper cope and lower drag sections defining a mold cavity therebetween and having gas passageways to said cavity, said cope section being provided with sand filling openings to said mold cavity;
   means mounting said cope and drag sections for relative vertical movement between them;
   carriage means mounted for horizontal reciprocal movement over said mold box;
   a sand magazine for filling said mold box through said filling openings mounted on said carriage means for movement therewith;
   a first gas manifold mounted on said carriage means for movement therewith;
   a second gas manifold adjacent said drag section;
   means mounting said mold box and second gas manifold for vertical reciprocal movement to and from said carriage means for disposing said cope section alternately adjacent said magazine and said first manifold, said first manifold enclosing said filling openings when adjacent to said cope section; and
   means effecting a seal between each of said gas manifolds and the mold box section adjacent thereto, said manifolds communicating with said passageways for conducting gas under pressure from one manifold to said mold cavity and from said mold cavity to the other manifold;

   wherein in said alternate dispositions of said cope section, sand containing a hardenable binder may be blown from said magazine into said mold cavity to thereby form a molded article therein, and a gaseous hardening agent for said binder may be blown from one of said manifolds into said mold cavity and exhausted to the remaining manifold to thereby harden said molded article; and
   wherein said mold box sections may be separated for removal of said molded article from said mold box.

5. Apparatus as defined in claim 4 including:
   stripper pins associated with said first gas manifold for movement with said carriage means and insertable vertically through the first manifold and said cope section for stripping a molded article from the cope section; and
   means for effecting relative vertical movement between said stripper pins, and said first manifold and said cope section.

6. Apparatus as defined in claim 5 including:
   second stripper pins associated with said second gas manifold and insertable vertically through the second manifold and said drag section for stripping a molded article from the drag section; and
   means for effecting relative vertical movement between said second stripper pins, and said second manifold and said drag section.

7. Apparatus as defined in claim 4 including a gas supply line connected to said one gas manifold, and pilot-operated pressure regulating valve means in said line for progressively increasing the gas pressure therein.

8. Apparatus as defined in claim 4 including inflatable sealing means interposed between said mold box sections.
9. A method of making a foundry sand article in a mold box having separable upper and lower box sections defining a mold cavity therebetween, one of said sections being provided with vertically extending sand filling openings to said cavity, which comprises the steps of:

positioning a sand magazine vertically adjacent to said mold box in communication with said filling openings,

blowing sand containing a hardenable binder from said magazine into said mold cavity to form a molded article therein;

horizontally separating said mold box and said magazine;

horizontally bringing a first gas manifold into vertical alignment with said mold box;

vertically interposing said mold box between said first gas manifold and a second gas manifold adjacent respective mold box sections in communication with said mold cavity, said first gas manifold enclosing said filling openings;

blowing a gaseous hardening agent for said binder from one of said gas manifolds into said mold cavity to harden said molded article while exhausting gas to the remaining manifold; and

vertically separating said mold box sections for removal of said molded article from said mold box.

10. A method as defined in claim 9 wherein said hardening agent is blown into said mold box at progressively increasing pressure, whereby said molded article hardens adjacent the points of introduction of said hardening agent sufficiently to prevent substantial erosion of the molded article thereat.

11. A method as defined in claim 9 including the step of removing said molded article from said mold box while separating said mold box sections by inserting stripper pins vertically through at least one of said gas manifolds and through its adjacent mold box section.

12. A method as defined in claim 9 wherein movement of said mold box is limited to vertical movement, and said sand magazine and said first gas manifold are moved horizontally into respective positions of vertical alignment with said mold box.